Trends in Furnace Cokemaking in the United States

July 27, 1999

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Functions of Metallurgical Coke in the Blast Furnace

- Produce reducing gas (CO) required for furnace operations
- Support the weight of the burden
- Act as a permeable base for easy gas movement
- Provide source of carbon for hot metal
- Provide heat to furnace
- Act as a filter for fine particles

Source: Bristow, N.J., BHP Coal Marketing, Coke Outlook 99.

Coke Production and Blast Furnace Productivity

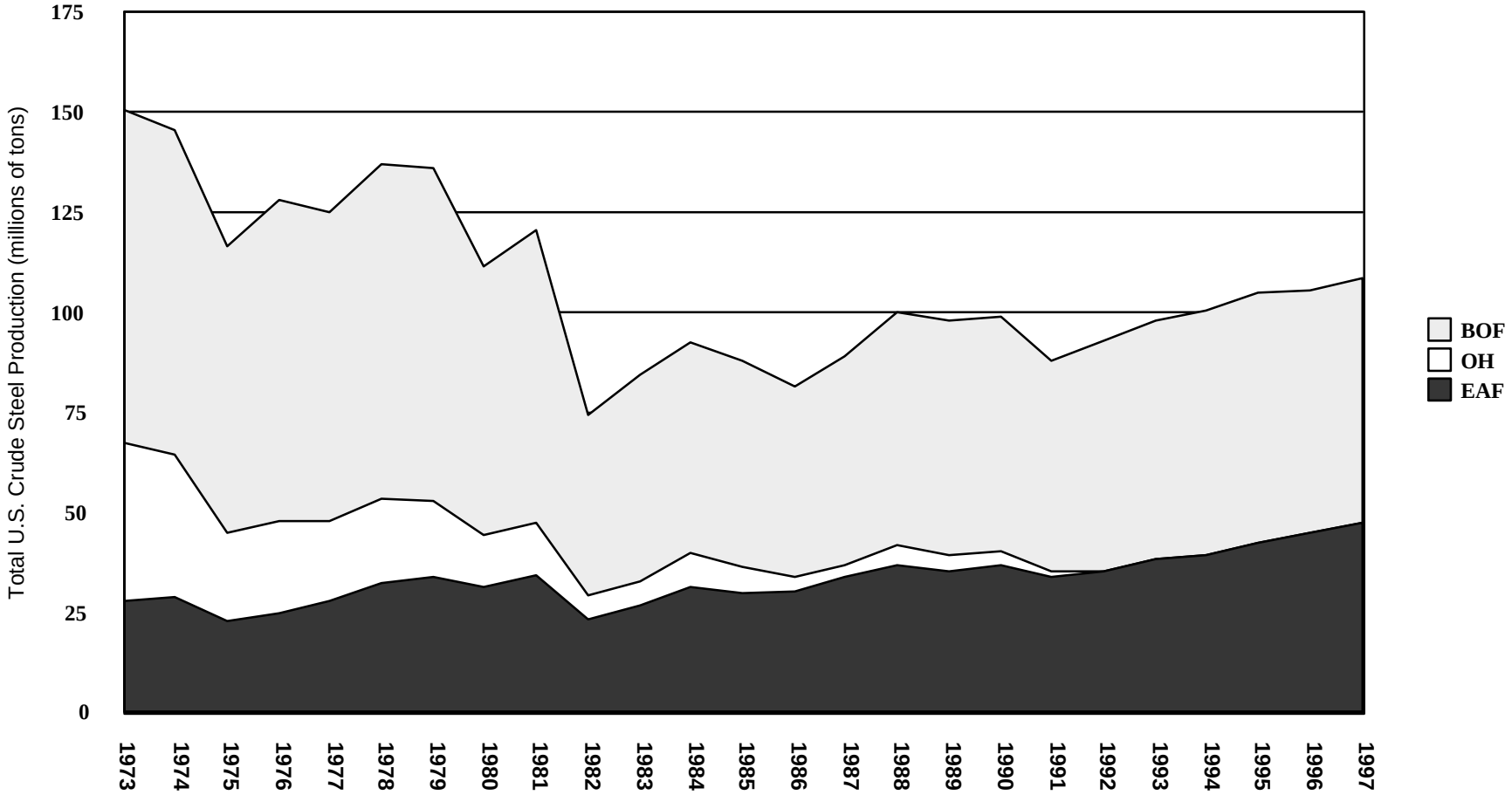
- Furnace coke demand in the US will be affected primarily by the following factors:
  - overall demand for steel based on the economy and the amount of that demand taken by steel imports
  - the relative amounts of certain grades of steel produced at integrated mills vs. non-integrated mills
  - improvements in blast furnace productivity from use of injectants to replace part of coke charge

Coke Production and Blast Furnace Productivity

- Although most new steelmaking capacity in the US will likely be added in the form of electric arc furnaces (EAFs), blast furnace/BOF steelmaking will remain a major factor in US and world steelmaking well into the next century.

Source: Agarwal, J.C., Charles River Associates, Coke Outlook 1999.

Figure 1
U.S. Crude Steel Production (1973-1997)
Basic Oxygen Furnace, Open Hearth Furnace, and Electric Arc Furnace



Source: AISI Annual Statistical Reports.

Coke Production and Blast Furnace Productivity

- Production capacity of hot metal in the US is expected to be maintained at about 60,000,000 tons/yr for the foreseeable future.

Source: Agarwal, J.C., Charles River Associates, Coke Outlook 1999.

Coke Production and Blast Furnace Productivity

- The level of hot metal production is expected to be maintained with fewer operating blast furnaces because of productivity improvements from increased use of PCI (pulverized coal injection), natural gas, oxygen and metallics.

Typical blast furnace productivity	7 to 8	tpd/100 ft^3 wv
Expected productivity improvements	10 to 12	tpd/100 ft^3 wv

(tpd/100 ft^3 wv, tons of hot metal per day per 100 ft^3 of furnace working volume)

Source: Agarwal, J.C., Charles River Associates, Coke Outlook 1999.

Coke Production and Blast Furnace Productivity

- Blast furnace coke rates (coke consumption) range typically from less than 700 lbs to more than 900 lbs of coke/NTHM at U.S. blast furnaces; minimum coke needs to support blast furnace operations are expected to be in the range of 600 lbs/NTHM.

  (lbs coke/NTHM, pounds of furnace coke per net ton of hot metal produced)

Sources: EPA 1997 Iron and Steel Survey
Agarwal, J.C., Charles River Associates, Coke Outlook 1999.

Coke Production and Blast Furnace Productivity

- Actual and projected US production of hot metal (molten iron), furnace coke and estimated furnace coke demand for the period 1976 to 2010 are presented below:

Year	Hot Metal Production[1] (mm tons/yr)	Approximate Coke Rate [2] (lbs/NTHM)	Apparent US Furnace Coke Demand (mm tons/yr)
1976	86.9	1,200	52.1
1980	68.7	1,140	39.1
1985	50.4	1,020	25.7
1990	54.8	1,000	27.4
1995	56.1	850	23.8
1997	54.7 56.3[3]	810[3]	22.8[3]
2000	~60.0[2]	~750	~22.5
2005	~60.0[2]	~675	~20.3
2010	~60.0[2]	~650	~19.5

Sources: (1) AISI Annual Statistical Reports
(2) Agarwal, J.C. Charles River Associates, Coke Outlook 1999
(3) EPA 1997 Iron and Steel Survey

Coke Production and Blast Furnace Productivity

- These projections imply minimum US furnace coke demand of approximately 18,000,000 tons/yr at 600 lbs coke/NTHM and 60,000,000 tons/yr of hot metal production

Possible CAA and CWA Regulatory Impacts

- 1990 Clean Air Act Amendments

MACT track:	achieve technology-based MACT standard by 12/31/1995
	achieve residual risk-based standard by 01/01/2003
Extension track:	achieve special, more stringent MACT standard by 11/15/1993
	achieve residual risk-based standard by 01/01/2020

MACT - Maximum Achievable Control Technology

Possible CAA and CWA Regulatory Impacts

- The CAA requirements provide for operation of existing by-product coke batteries designated under the *MACT track* beyond January 1, 2003, if residual risk standards are met; and, for batteries designated under the *extension track*, until at least January 1, 2020.

Possible CAA and CWA Regulatory Impacts

- Possible revisions to 40 CFR Part 420 may require upgrades at a number of existing by-product coke plants to meet revised BAT or PSES by 2005.

Alternate Cokemaking Technologies

- At present, there are three cokemaking technologies that produce coke suitable for blast furnace operations, and that are demonstrated fully on a commercial scale:

  conventional by-product coke plants
  non-recovery or heat-recovery coke plants
  beehive coke plants (China)

  An alternative technology (Antaeus Process) is being developed commercially *(Barber, S.J., Antaeus Energy, Coke Outlook 1999).*

Alternate Cokemaking Technologies

- The following technologies have not been demonstrated fully on a commercial scale, or have not produced coke suitable for use in blast furnace operations:

  Early formcoke processes *(Japan)*
  SCOPE 21 *(Japan)*
  Calderon Process *(US)*
  Ukranian Continuous Cokemaking Process

Source: Bristow, N.J., BHP Coal Marketing, Coke Outlook 99.

Alternate Cokemaking Technologies

- Because of environmental considerations and with availability of third-party financing, it is likely that most new coke plants built in the US over the near term (0 to 5 years) will be of the heat recovery design.

Alternate Cokemaking Technologies

- An extension of a by-product battery was approved for construction in Indiana *(Citizens Gas and Coke, Indianapolis, IN)*.

Approximate Investment Costs for New or Modified Cokemaking Facilities

- New heat recovery coke plant $350 mm
  (1.2 to 1.3 mm tons annual capacity)
  (Includes coal handling, coke plant and energy recovery facilities)

  Source: Indiana Harbor Coke

- Pad-up rebuild of <u>one</u> by-product > $100 to > $200 mm
  coke plant battery
  (approximately 250,000 to 500,000 tons per year)

  Source: Steel Industry

- Addition of new by-product coke battery to $220 to $300 mm
  existing coke plant (Includes infrastructure requirements;
  less than 1 to 1 mm tons annual capacity)

  Source: Citizens Gas & Coke

Approximate Investment Costs for New or Modified Cokemaking Facilities

- Possible upgrade to meet revised CWA BAT for by-product plant — $0 to $10 mm

  Source: Amendola Engineering

- Possible costs to comply with CAA residual risk standards — To be determined

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